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ABSTRACT

This study focuses on the body composition and anthropometric measurements of 65 college football players. Body composition was determined by underwater weighing with an accurate assessment of residual volume. The anthropometric measurements included height, weight, seven skinfolds, waist circumference, and wrist diameter. A step-wise multiple regression analysis of the data indicated that body density and body fat could be predicted from anthropometric measurements. A multiple correlation of .96 was found between body density and the following three independent variables: (a) waist circumference, (b) triceps skinfold, and (c) height.) The team data were divided into five categories by position. When subjected to analysis of variance, significant differences at the .01 level suggested that at least two separate groups, backs and linemen, be used in future body composition studies of football teams. The estimated optimal playing weights of each player were determined by densitometry, and each player and the coach estimated their optimal weights through personal experience. It was found that the players and the coach estimated the players optimal mean weight to be six and nine pounds heavier, respectively, than the densitometric analysis indicated as optimal. (Author/JS)

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THE BODY COMPOSITION OF A COLLEGE FOOTBALL TEAM

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Since the inception of American football, its players have tried to adjust their weight for maximal performance at their position. Although much thought has been given to the problem by players, coaches, trainers, and parents, their approach has been primarily of the intuitive nature. Only on a few occasions has the problem been approached scientifically[3,7,13,20]. It appears that players and coaches tend to regard total body weight as the primary criterion[20], although several studies have demonstrated that responses measured by physical performance tests were inversely related to percentage of body fat, while having no relationship with total body weight[5,9,18].

With the above in mind, it was the purpose of this investigation to study the following problems: (1) to collect densitometric and anthropometric data on an entire college football team, (2) to compare the body composition of football players by position, (3) to develop a regression equation to predict body density from anthropometric measurements, (4) to compare data on football players in similar studies with those obtained from the present study and (5) to compare optimal playing weight as determined by densitometric techniques with player and coach perceptions of optimal playing weight.

Methods

The subjects consisted of 65 candidates for spring football practice at St. Cloud State College, Minnesota who ranged in age from 17 to 23 years. The subjects were divided by position into five categories according to Wilmore and Haskell[20]. The categories and the number of subjects were as follows: defensive backs (N = 15), offensive backs and receivers (N = 15), linebacks (N = 7), offensive

linemen and tight ends (N = 13), and defensive linemen (N = 15).

The skinfold measurements were administered by the investigator who had previously established reliability with a Lange skinfold caliper (Cambridge Scientific Industries, Inc.). The general procedures used in taking the skinfolds were those described by Brožek[1]. The specific skinfolds were chest[8]; thigh, scapula, and triceps[10]; pectoral and iliac crest[21]; and abdomen[17]. The wrist diameter was taken with a stainless steel Vernier caliper read to 0.1 centimeter from the most lateral projection of the styloid processes of the radius and ulna[21]. Waist girth was taken by placing the steel tape just superior to the iliac crests laterally and the umbilicus anteriorly and was read to 0.1 centimeter[21]. The average of three trials was accepted for each measurement.

Body composition was assessed for all subjects by the hydrostatic weighing technique as described by Wilmore[14] and by Wilmore and Behnke[16]. Five to eighteen weighings were performed, and the criteria for the reading used was as follows: (1) the greatest weight recorded if observed more than twice, (2) the second greatest weight if observed more than once, or (3) the third highest value. Almost without exception the maximum weight was observed three or four times with these highly motivated subjects.

Residual volume was determined by the "closed-circuit oxygen-dilution method" as described by Wilmore[15]. Two tests within 50 milliliters were averaged and accepted as the residual volume. Body density was determined by the formula described by von Döbeln[12]. Percent fat and lean body mass were calculated from the formula developed by Brožek, et al.[2].

A Univac 1100 computer was used to compute all of the zero-order correlations, multiple correlations and regression equations. The step-wise linear regression technique was used for the multiple correlations and regression analysis.

Results and Discussion

The data were analyzed for the entire team and for five categories according to position previously described by Wilmore and Haskell[20]. These data are presented in Table I.

The means seem to follow a pattern which, with minor variations, progressed from smallest to largest in the following order: defensive backs, offensive backs and receivers, linebackers, defensive linemen, and offensive linemen and tight ends. As might be expected, the first two groups were very similar, as were the last two. The linebackers exhibited means tending toward those of the backs, although in height and weight they were midway between the backs and linemen.

The matrix of zero-order correlations presented in Table II demonstrated that the criterion, body density, had high correlations ($\underline{r}$ = -.80 to $\underline{r}$ = -.92) with nine of the eleven independent variables. These high correlations between body density and selected anthropometric measurements generally support the findings of other studies. The correlations between body density and the skinfolds[10,17,21] and waist circumference[17,21] are higher than in previous investigations. The lack of significance between body density correlations with wrist diameter and height noted in the present study have been previously demonstrated.

TABLE I

Means and Standard Deviations of College Football Players by Position

Variable	Unit	Total Team N = 65 Mean	S.D.	Defensive Backs N = 15 Mean	S.D.	Offensive Backs and Receivers N = 15 Mean	S.D.
Age	years	19.7	1.31				
Height	cm.	182.5	5.75	178.3	3.15	179.7	6.26
Weight	kg.	88.1	12.12	77.3	3.93	79.8	7.98
Densiometric Data							
Underwater Weight	kg.	4.6	.69	4.51	.53	4.57	.54
Residual Volume	liters	1.458	.295	1.501	.20	1.425	.34
Body Density	gm/cc	1.0648	.0143	1.0736	.0067	1.0714	.0134
Fat Weight	kg.	13.8	7.19	8.8	2.14	10.2	4.96
Lean Body Weight	kg.	74.2	6.51	68.4	3.90	69.6	4.81
Per Cent Fat	per cent	15.04	5.83	11.5	2.65	12.4	5.33
Anthropometric Data							
Pectoral	mm.	7.6	3.51	5.4	1.84	6.5	2.67
Tricep	mm.	10.3	3.58	8.7	2.27	9.1	3.38
Scapula	mm.	12.5	5.29	8.9	1.73	9.8	2.88
Chest	mm.	10.8	5.93	7.1	2.65	7.8	4.01
Iliac	mm.	21.6	9.80	16.1	6.43	15.5	7.64
Abdomen	mm.	18.7	8.96	12.9	4.26	14.3	7.15
Thigh	mm.	12.1	4.26	10.1	2.67	10.3	4.09
Waist	cm.	88.6	9.55	81.1	2.98	82.6	6.42
Wrist	cm.	6.2	.31	6.1	.22	6.1	.27

Table I (Continued)

Variable	Unit	Linebackers N = 7 Mean	S.D.	Offensive Linemen and Tight Ends N = 13 Mean	S.D.	Defensive Linemen N = 15 Mean	S.D.
Age							
Height	cm.	182.1	4.34	186.0	4.62	186.6	4.40
Weight	kg.	87.2	5.79	99.2	9.02	97.8	9.68
Densiometric Data							
Underwater Weight	kg.	5.00	.46	4.45	1.04	4.65	.64
Residual Volume	liters	1.401	.40	1.540	.29	1.402	.30
Body Density	gm/cc	1.0687	.0102	1.0549	.0170	1.0561	.0106
Fat Weight	kg.	11.8	4.33	19.4	8.67	18.4	6.30
Lean Body Weight	kg.	75.4	3.05	79.8	4.11	79.3	4.60
Per Cent Fat	per cent	13.4	4.10	19.1	7.02	18.5	4.38
Anthropometric Data							
Pectoral	mm.	6.3	2.51	10.4	4.95	9.0	2.32
Tricep	mm.	9.7	3.86	12.4	3.94	11.7	3.38
Scapula	mm.	11.4	3.15	16.3	6.70	16.0	5.02
Chest	mm.	7.9	4.01	15.9	6.91	14.2	4.99
Iliac	mm.	18.4	8.53	28.3	8.56	28.9	8.28
Abdomen	mm.	17.0	7.02	24.4	10.20	24.9	7.55
Thigh	mm.	12.8	4.69	14.3	5.32	13.6	3.21
Waist	cm.	86.8	5.92	97.3	9.43	95.5	7.31
Wrist	cm.	6.3	.17	6.3	.31	6.4	.42

The step-wise multiple regression analysis was used to determine which anthropometric measures would provide the best estimate of body density. An R of .96 was found between body density and three independent variables (waist circumference, tricips skinfold, and body height). An R of .96 was also found between percent fat and the same three variables.

B.D. = 1.10148 - 0.00118 (waist circumference - 0.00114 (triceps SF) + .00044 (height) $\pm$ 0.0041

Percent Fat = 0.17754 + 0.48441 (waist circumference) + 0.45752 (triceps SF) 0.17973 (height) $\pm$ 1.64

Waist circumference measured in centimeters.

Skinfolds measured in millimeters.

Height measured in centimeters.

TABLE 2

Matrix of Zero-Order Correlations

	2	3	4	5	6	7	8	9	10	11	12
1	-.20	-.81	-.82	-.82	-.85	-.86	-.86	-.87	-.80	-.92	-.06
2		.57	.14	.19	.27	.21	.33	.22	.20	.41	.45
3			.65	.67	.77	.75	.81	.78	.67	.92	.41
4				.80	.88	.86	.80	.84	.72	.76	-.02
5					.77	.72	.79	.74	.83	.72	.06
6						.84	.87	.87	.73	.84	.03
7							.84	.86	.63	.85	.03
8								.91	.74	.87	.15
9									.71	.86	.07
10										.73	.02
11											.22

Key:

1. Body Density
2. Height
3. Body Weight
4. Pectoral)
5. Tricep)
6. Scapular)
7. Chest) Skinfolds
8. Iliac)
9. Abdomen)
10. Thigh)
11. Waist Circumference
12. Wrist Diameter

.05 level of confidence = .24

.01 level of confidence = .31

Analysis of variance was used to determine if the five subgroups were significantly different in body density, body weight, fat weight, lean body weight and percentage of fat. The F ratios were significant beyond the .01 level of confidence in each instance, and ranged from 7.36 to 24.20 (.01 level = 3.65 with 4/60 degrees of freedom). The mean differences were highly significant (.01 level of confidence) when comparing the backs with linemen. No significant difference occurred between the offensive and defensive backs or between the offensive and defensive linemen.

These differences would appear to suggest that football players should be divided into at least two groups, backs and linemen, if not into five groups used in the Wilmore and Haskell[20] study and the present study when studying body composition trends.

As a result of these basic body compositional differences between the backs and linemen, regression equations were developed for each. For the backs, an R of .97 was found between body density (also percent fat) and four independent variables. The R for the linemen remained at .96. The equations are as follows:

BACKS AND RECEIVERS

Body Density = 1.02451 - 0.00069 (abdomen SF) - 0.00130 (thigh SF) + 0.01263 (wrist diameter) - 0.00073 (triceps SF) $\pm$ 0.0030.

Percent Fat = 31.09000 + 0.27816 (abdomen SF) + 0.50982 (thigh SF) - 5.03271 (wrist diameter) + 0.28887 (triceps SF) $\pm$ 1.16.

LINEMEN, LINEBACKERS & TIGHT ENDS

Body Density = 1.17446 - 0.00109 (waist circumference) - 0.00072 (triceps SF) - 0.00038 (chest SF) $\pm$ 0.0041.

Percent Fat = -30.50715 + 0.45316 (waist circumference) + 0.29294 (triceps SF) + 0.15044 (chest SF) $\pm$ 1.65

Skinfolds measured in millimeters.

Diameters measured in centimeters.

Circumferences measured in centimeters.

As a result of examining the data for the backs and linemen separately, the regression equation for the backs was improved. The R increased from .96 to .97 and the standard error of the estimate decreased from 0.0041 to 0.0030. No improvement was made in the equation for the linemen with the R and standard error of the estimate remaining the same.

In an effort to further demonstrate the need for dividing football players into two groups when studying body composition, the team equation was applied to the linemen and to the backs separately. The standard error of the estimate remained unchanged for the linemen (.0041 to .0042) but remained high for the backs (.0030 to .0041). The equation developed for linemen was then utilized to predict the back's body density, with the standard error of the estimate increasing to .0060. When the equation developed for the backs alone was used to predict the body density of the linemen, the standard error of the estimate increased to .0101. These findings would appear to support the contention that separate equations for predicting the body densities of backs and linemen should be employed. Perhaps the relative leanness of the backs made it possible to be more accurate in taking the anthropometric measurements than it was for the fatter linemen. This may have made it possible for the development of a more accurate equation for the backs than was possible for the linemen.

The present study was compared with other studies involving football players[3,4,7,11,13,20]. The college teams were smaller and fatter in every respect than the three professional teams studied. A comparison of the data from the present study with that of the Wilmore and Haskell study[20] are presented in Table III.

Each player was asked what he felt his best playing weight for the coming spring practice would be. The head coach responded to the same question on each player. At the same time, the investigators estimated each players' "ideal weight" based upon the results of the Wilmore and Haskell study[20]. The selected "ideal weights" were: 8 percent for defensive and offensive backs and receivers; 15 percent for linebackers, offensive linemen and tight end; and 18 percent for defensive linemen. It was found that the players perceived their "ideal weight" to be 9.1 pounds heavier than the ideal weight selected by the investigators. The coach also overestimated the weight by 6.2 pounds. This finding, in conjunction with a negative correlation of .69 between percentage of fat and 40 yard dash speed for players evaluated in the present study, would appear to indicate the need for increased emphasis in making recent body compositional findings more accessible to football coaches and players. It appears that far too much emphasis is placed upon total body weight and too little emphasis on lean body weight by the coach and the athlete.

The present study also emphasizes the body compositional differences that may occur between athletes in the same sport. The linemen were basically heavier and fatter than the backs and wide receivers. Prediction of body density and fat was inhanced by developing a specific equation for the backs and wide receivers. This supports the contention that regression equations for the prediction of body density appears to be specific even among athletes in the same sport[3]. There is an apparent need for further studies of this nature among individual sports that cover a diversity of body composition types.

TABLE III

Comparisons of Body Composition Means by Position Between Professional Football Players and College Football Players

Position	Level	N	Height cm.	Weight kg.	Per Cent Fat	Fat Weight kg.	Lean Body Weight	Body Density gm/cc
Defensive Backs	pro[1]	4	184.4	85.0	7.7	6.6	78.4	
	college	15	178.3	77.3	11.5	8.8	68.4	1.0736
			(3.15)	(3.93)	(2.65)	(2.14)	(3.90)	(.0067)
Offensive Backs and Receivers	pro	10	184.2	91.8	8.3	7.7	84.1	
	college	15	179.7	79.8	12.4	10.2	69.6	1.0714
			(6.26)	(7.98)	(5.33)	(4.96)	(4.81)	(.0134)
Linebackers	pro	6	189.7	107.6	18.5	19.9	87.7	
	college	7	180.1	87.2	13.4	11.8	75.4	1.0687
			(4.34)	(5.79)	(4.10)	(4.33)	(3.05)	(.0102)
Offensive Linemen and Tight Ends	pro	12	193.5	113.2	15.5	17.8	95.4	
	college	13	186.0	99.2	19.1	19.4	79.8	1.0549
			(4.63)	(9.02)	(7.02)	(8.67)	(4.11)	(.0170)
Defensive Linemen	pro	12	192.9	120.6	18.7	22.9	97.7	
	college	15	186.6	97.8	18.5	18.4	79.3	1.0561
			(4.40)	(9.68)	(4.38)	(6.30)	(4.60)	(.0106)
Total	pro	44	190.2	107.0	14.4	16.2	90.9	
	college	65	182.5	88.0	15.0	13.8	74.2	1.0648
			(5.75)	(12.12)	(5.83)	(7.19)	(6.51)	(.0143)
Range	pro		177-202	81-143	4-29	3-39	73-107	
	college		166-195	70-120	4-31	3-35	61-87	1.0272-1.0931

[1]The 44 professional players were evaluated by Wilmore and Haskell (20)

The numbers in parenthesis are standard derrations from the present study.

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